

REHABILITATION OF SMALL AND MEDIUM SPAN CONCRETE BRIDGES

- SOME EXAMPLES -

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INDEX

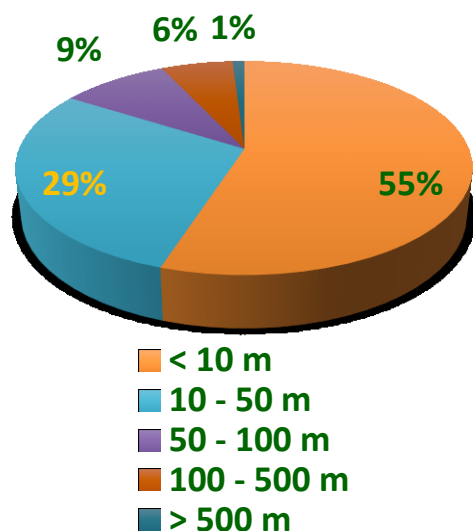
1. INTRODUCTION
 - a. Defects
 - b. Solutions
2. EXAMPLE 1 – URBAN VIADUCT
 - a. Structural defects
 - b. Structural rehabilitation
3. EXAMPLE 2 – ANCIENT RAILWAY BRIDGE
 - a. Structural defects
 - b. Structural rehabilitation



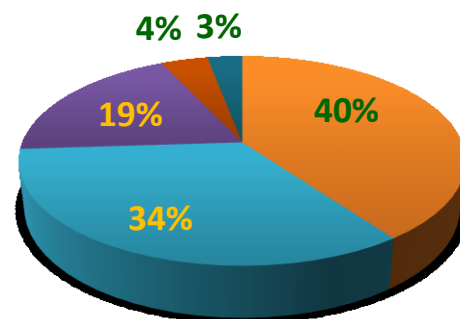
1. INTRODUCTION

The majority of the bridges have small and medium and are built using reinforced concrete or prestressed concrete.

These kind of bridges have an important role in the maintenance budgets of any country.



Percentage of bridges per span length
in Portugal



Percentage of bridges per type of structure
in Portugal

1. INTRODUCTION

a. Defects

During the design working life, concrete bridges are:

- exposed to severe environmental attack;
- are subjected to accidental mechanical actions from traffic;

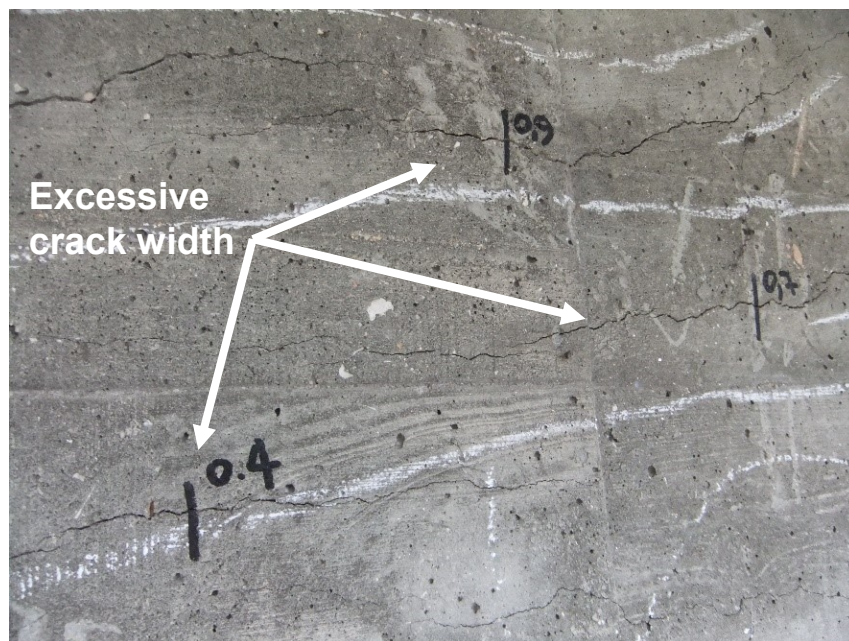


1. INTRODUCTION

a. Defects

During the design working life, concrete bridges are:

- may be damaged due to excessive loading;
- may develop defects due to construction errors.



Example of construction error.

1. INTRODUCTION

a. Defects

During the design working life, concrete bridges are:

- and may develop defects due to design errors.



**Example of
reinforcement failure
due to design error.**

1. INTRODUCTION

b. Solutions

The rehabilitation of concrete bridges usually include:

- the repair or replacement of the bridge elements, as the bearings, expansion joints, parapets, safety barriers, fascia, rain water drainage systems, footpaths, deck bituminous surfacing, anti-corrosion protection of steel elements and concrete finishes;

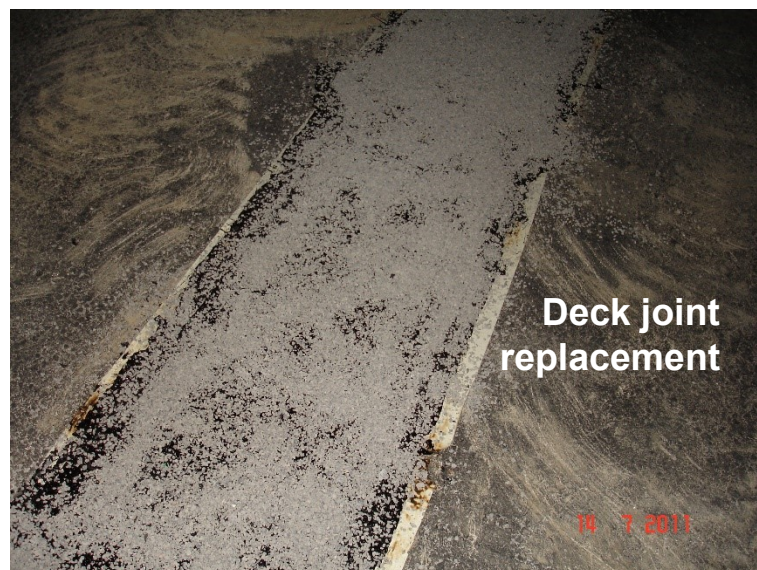


1. INTRODUCTION

b. Solutions

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1. INTRODUCTION

b. Solutions

The rehabilitation of concrete bridges usually include:

- removal of vegetation and large woody debris from the watercourse;
- repair of reinforcement and prestress steel corrosion, including the concrete reshape with structural grouts;
- Sealing or injection of cracks;
- repair due to damages caused by accidental mechanical actions from traffic;
- and the strengthening of the structure:
 - if damaged by overloading,
 - in order to enlarge the deck or increase the traffic loading,
 - or to correct design or/and construction errors.



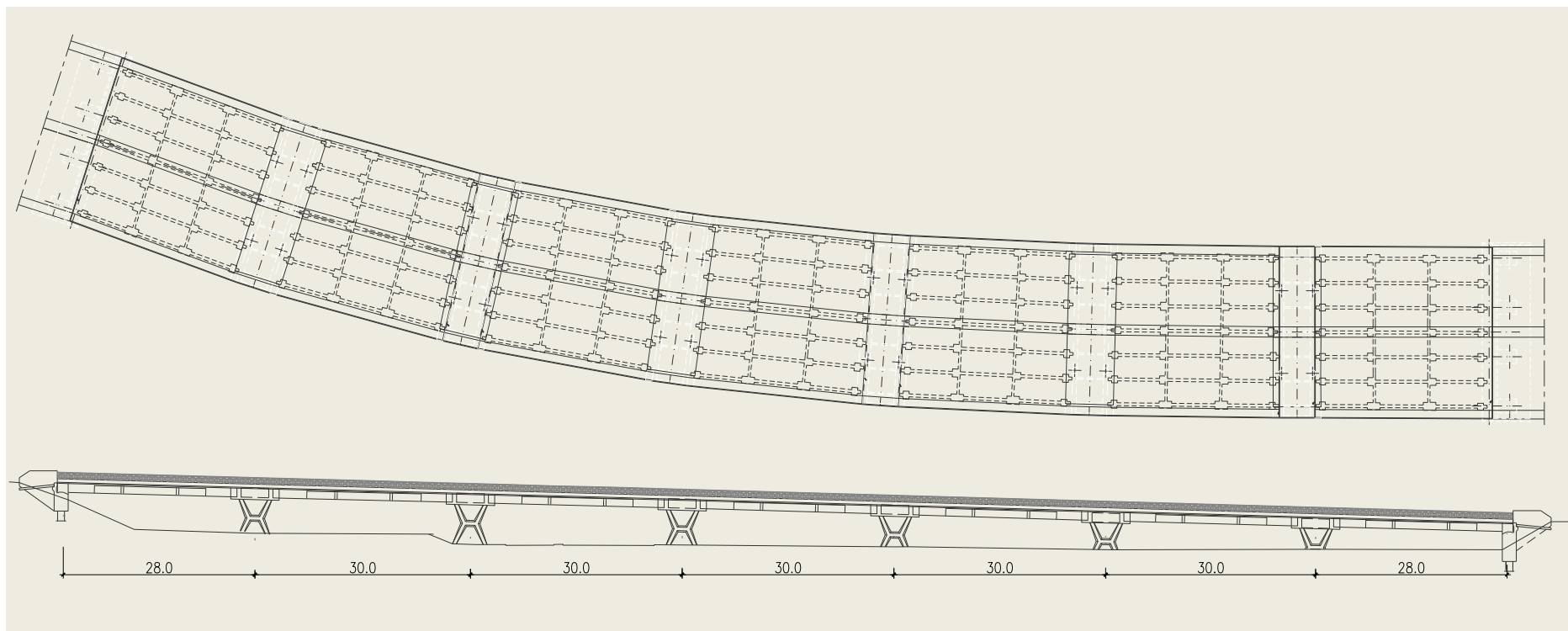
2. EXAMPLE 1 – URBAN VIADUCT

The first example is a viaduct in Lisbon, in a very busy traffic road.

Due to construction faults,
this structure presented:

- reinforcement corrosion problems,
- damages in parapets and fascia,
- excessive cracking and deformation in prestressed main beams,
- and crushed bearings.





Viaduct in Lisbon.

The deck is 25 m wide.

It has 7 spans, with longitudinal prestressed concrete beams 25m long.

The deck is supported by transversal frames with columns with X shape and a box girder.

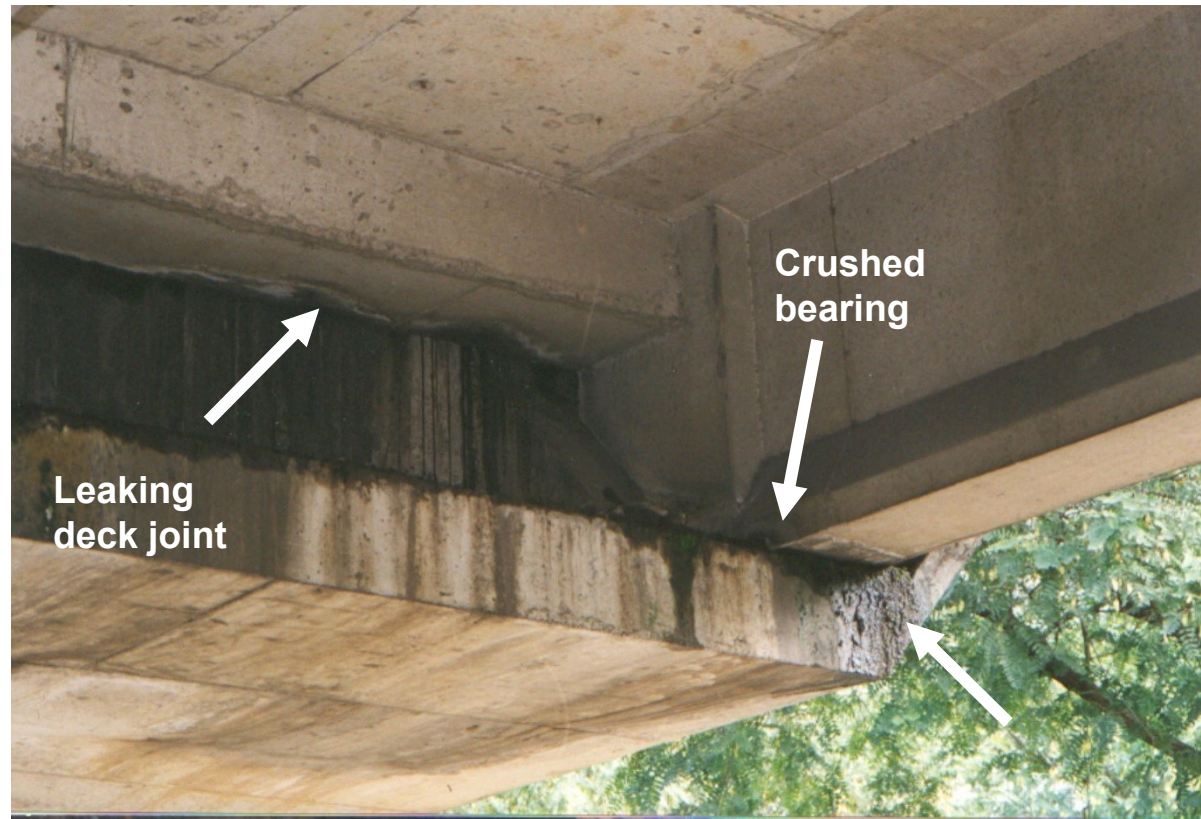
There are transversal beams over the supports and at 1/3 of the span.



2. EXAMPLE 1 – URBAN VIADUCT

a. Structural defects

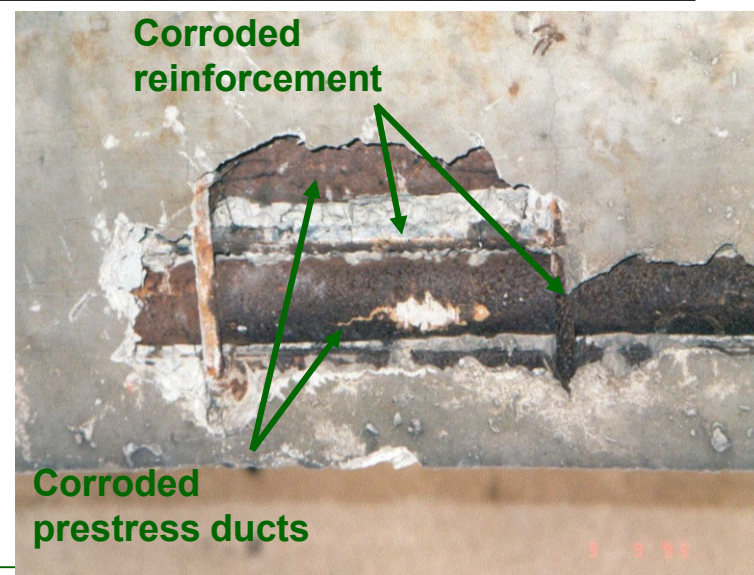
- Deterioration of the deck joints and degradation of the surrounding structure;
- Neoprene bearings crushed;



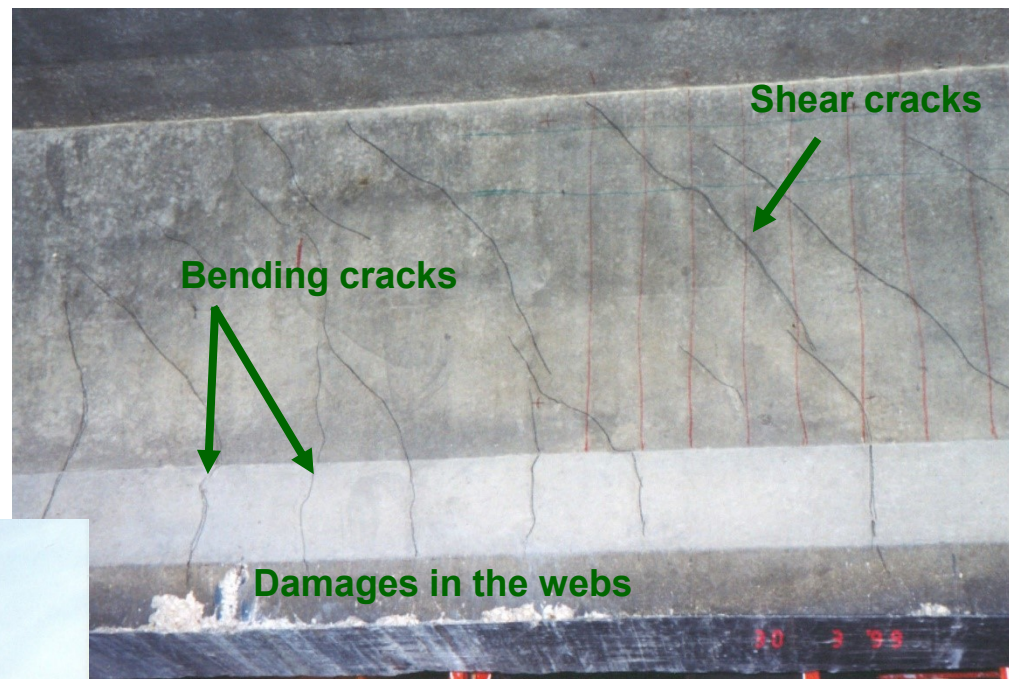
- Columns, transversal box girders, longitudinal beams and facies with reinforcement corrosion and concrete delamination;



- Exposed prestress anchorages and ducts, with corrosion.



- Excessive deformation of the main beams, also with excessive cracking due to shear and bending;
- Damages due to accidental loading in the bottom flange of the main beams and in the parapets.



- Obstructed drainage system and deterioration of the lightening system.

2. EXAMPLE 1 – URBAN VIADUCT

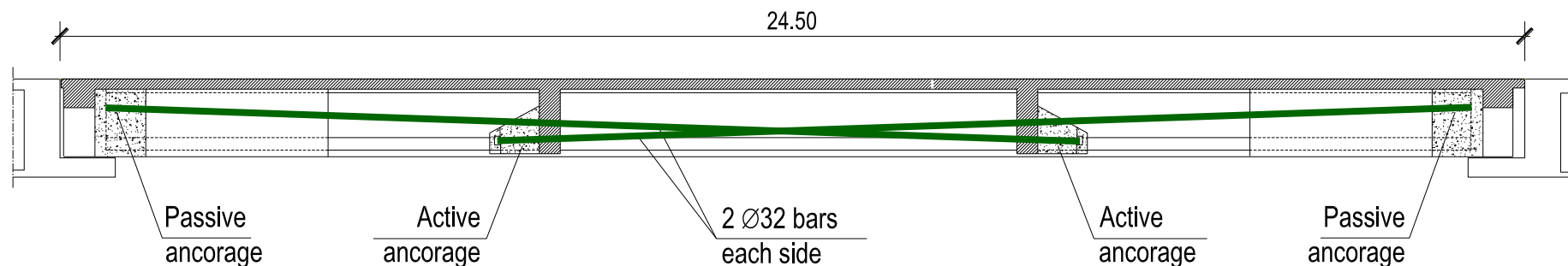
b. Structural rehabilitation

Objectives for the main beams:

- Improve the bending and shear resistance;
- Reduce the deformation and close the bending and shear cracks.

Solution:

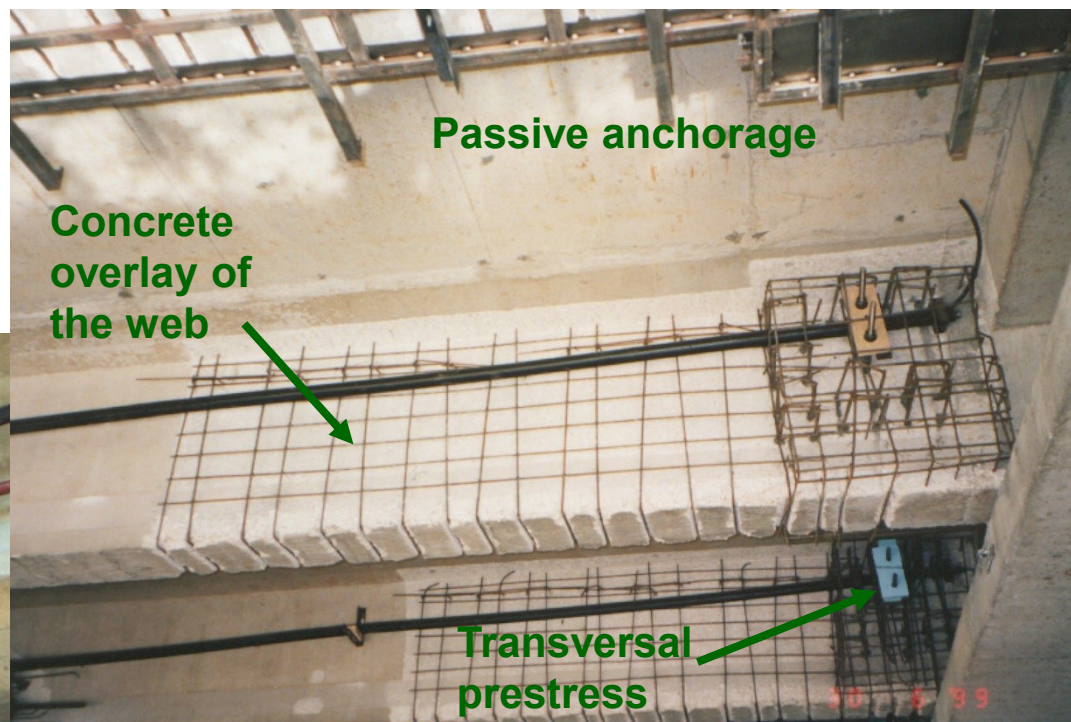
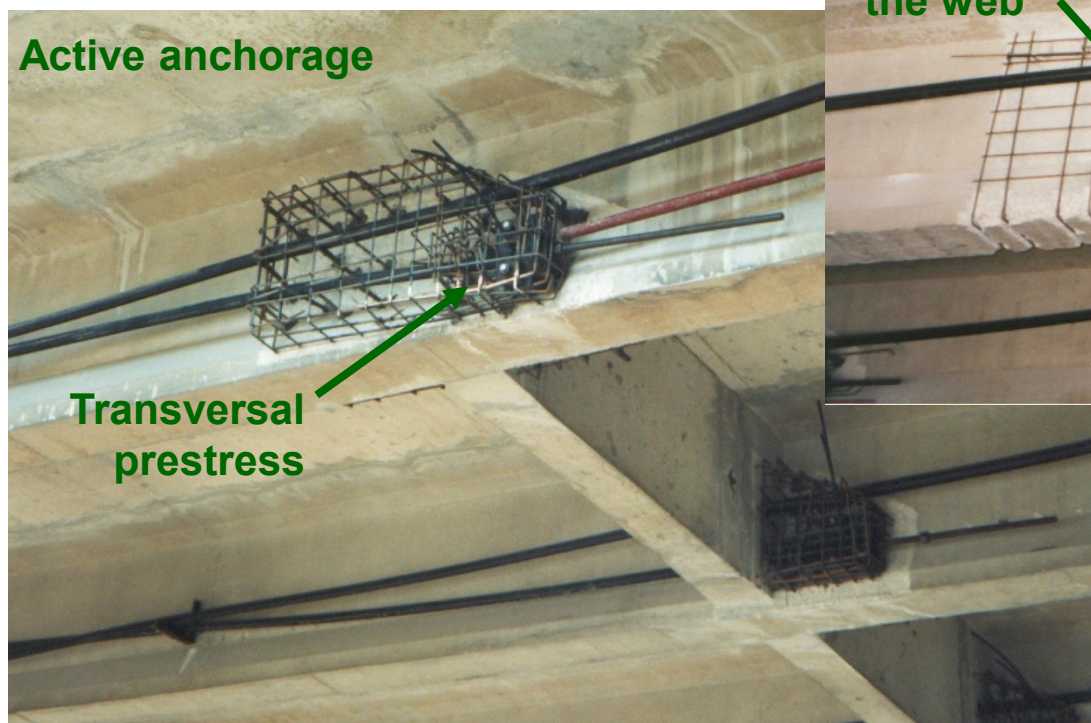
- External prestress with inclined bars, anchored in concrete blocks;
- Concrete overlay in the webs near the supports.



2. EXAMPLE 1 – URBAN VIADUCT

b. Structural rehabilitation

- External prestress with inclined bars, anchored in concrete blocks;



- Concrete overlay in the webs near the supports.

2. EXAMPLE 1 – URBAN VIADUCT

b. Structural rehabilitation

Other rehabilitation works:

- Cleaning of the corroded reinforcement and concrete reshape with structural grout;
- Injection of some cracks with epoxy resin;
- Painting the concrete surface with acrylic paint in order to control the concrete carbonation process;
- Replacement of the
 - neoprene bearings,
 - the deck joints,
 - the bituminous surfacing,
 - the drainage system,
 - the fascia,
 - and the parapets.



2. EXAMPLE 1 – URBAN VIADUCT

b. Structural rehabilitation



3. EXAMPLE 2 – ANCIENT RAILWAY BRIDGE

This example includes the inspection, diagnosis, repair and strengthening of an historical railway bridge in Algarve, in the south of Portugal, named Farelo River Bridge. This bridge is 4 km far from the Atlantic Ocean.

This bridge is the oldest reinforced concrete railway bridge in use in Portugal. It was built in 1913 by a Portuguese contractor.

The bridge was designed by François Hennebique, a famous French engineer who patented his pioneering reinforced concrete construction system in 1892.

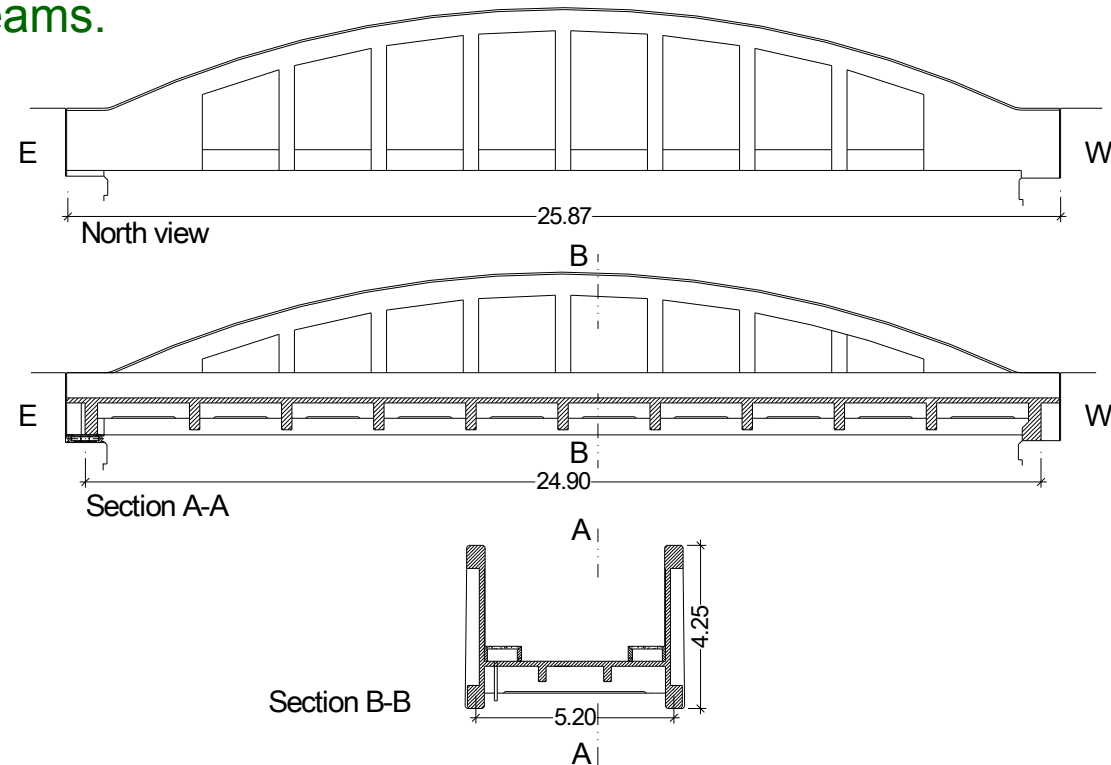
The Farelo River Bridge is a tie-arch bridge with a span of 24.90 m.

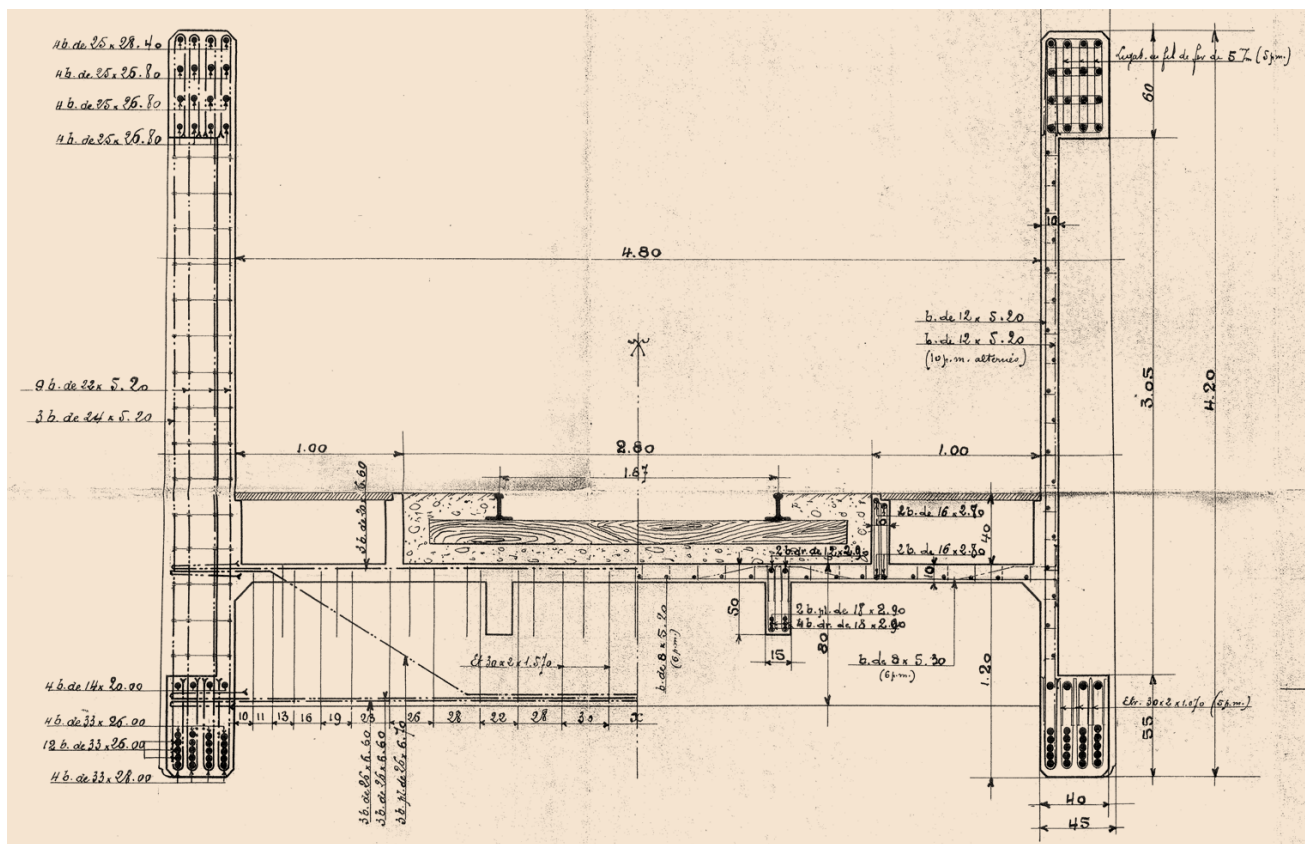


The bridge includes two arches and a lower deck that holds the horizontal tie forces of the arch. There are vertical ties that transfer the deck loads to the top chord. Concrete walls close the areas between the ties, the deck and the top chord.

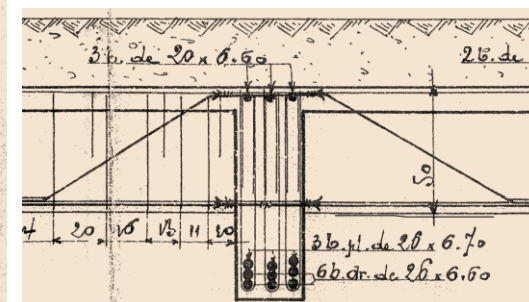
The deck has transversal beams, held by the vertical ties, two longitudinal main beams, in the arches planes, and two secondary longitudinal beams.

The abutments are made of stone masonry.





Arch cross section



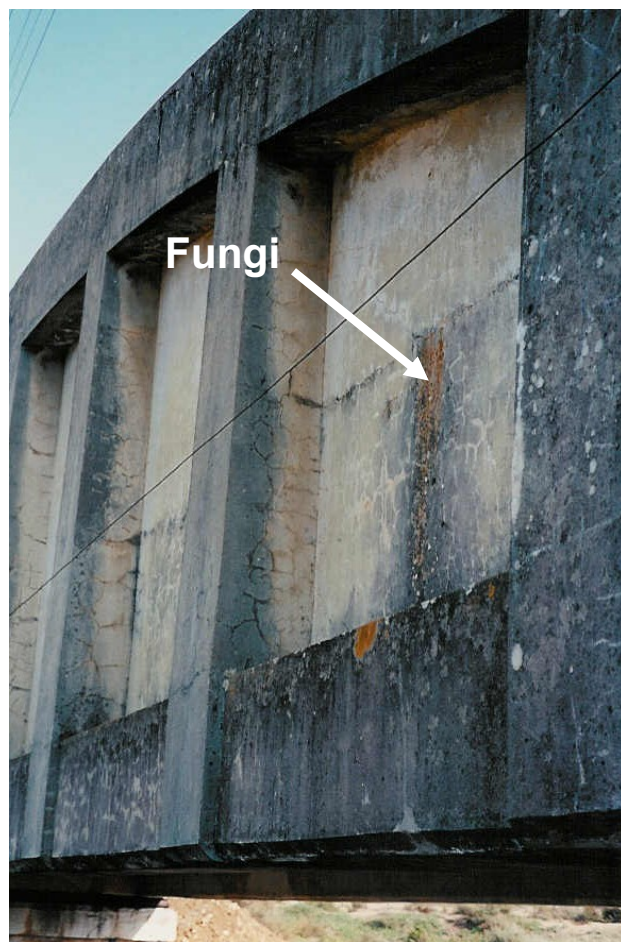
Transversal beam cross section



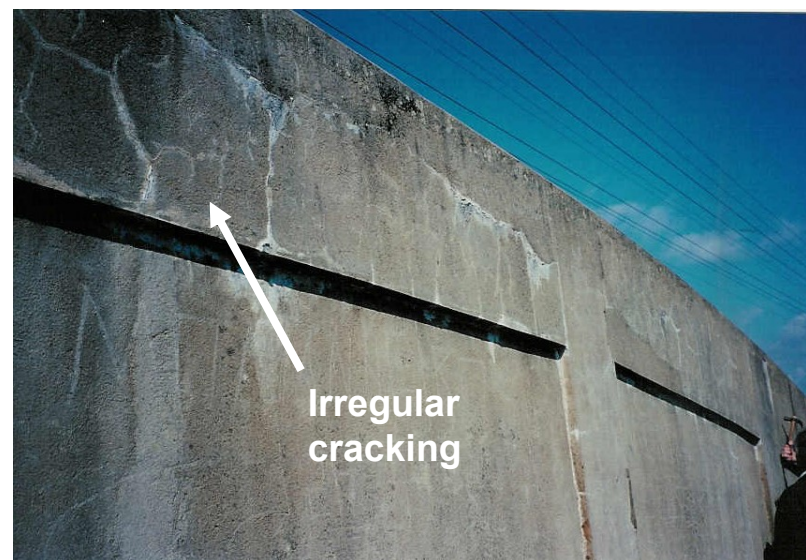
Construction details of the Farelo River Bridge (François Hennebique design office, 1913)

3. EXAMPLE 2 – ANCIENT RAILWAY BRIDGE

a. Structural defects



All the concrete surface was rendered with a cementitious grout. This render had an irregular cracking pattern, due to differential shrinkage, and in many places it was loose from the concrete base. On the North side, not exposed to sun beams, there were fungi that kept the humidity on the surface.



Concrete strength, steel strength and concrete carbonation tests were performed.

Electrical potential for corrosion, as well as identification of reinforcement, was done.

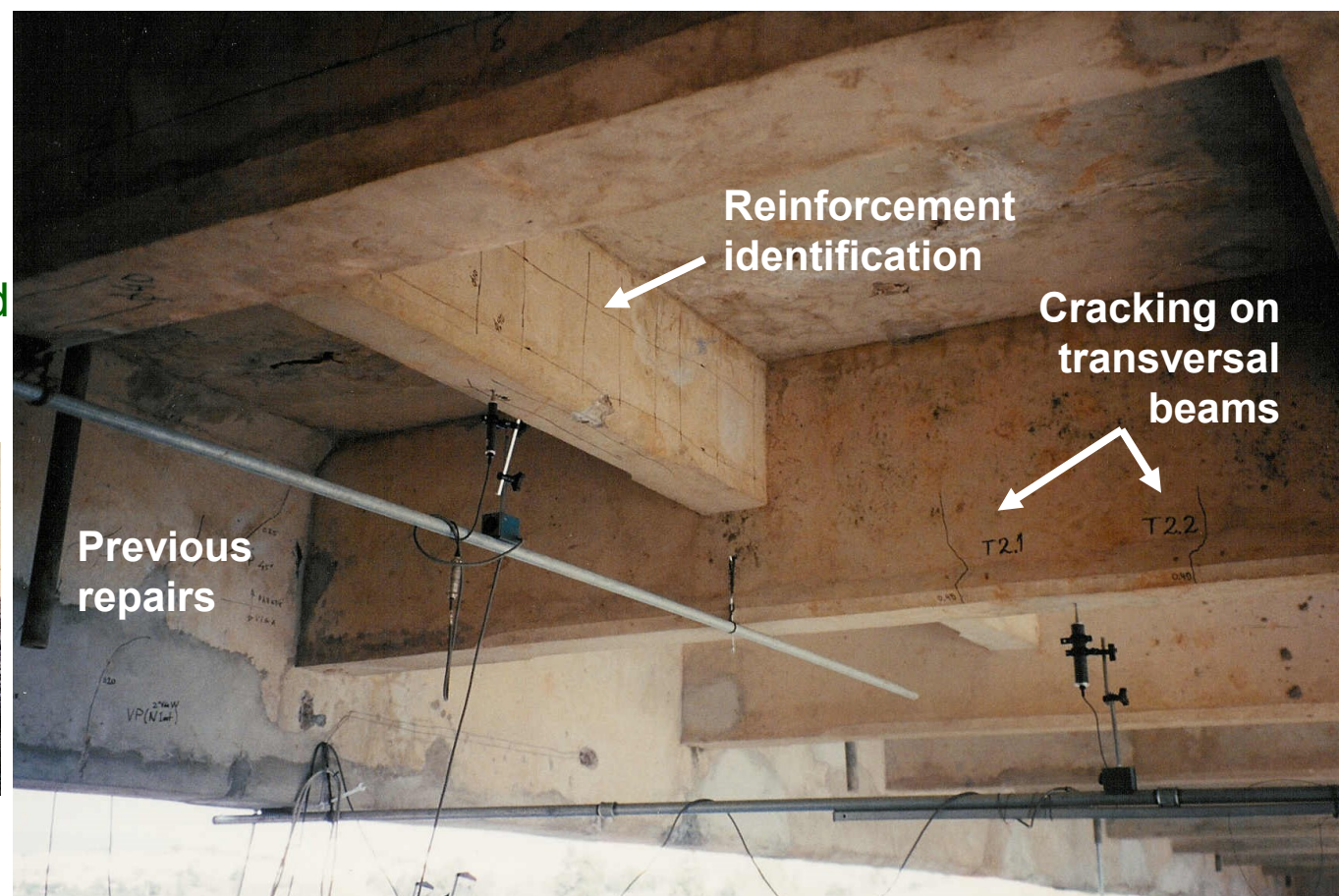


Monotonic and dynamic loading tests were done, with measurements of displacements in several points of the bridge deck.

A numerical analysis of the structure was performed and the results were compared with the experimental ones.



**Data logger and
computer for the
loading tests**



View of the displacement transducers below the deck

3. EXAMPLE 2 – ANCIENT RAILWAY BRIDGE

b. Structural rehabilitation

The numerical analysis and the tests revealed that the transversal beams were not verifying safety for bending and crack widths.

The transversal beams were strengthened with external prestress for bending resistance and crack width control.

Each transversal beam was prestressed with two 26.5 mm diameter high strength steel bars, inside high density polyethylene ducts injected with grout.



The repair works consisted on:

- replacing the loose render by shrinkage controlled grout;
- repairing the areas of concrete with reinforcement corrosion;
- improving the drainage system and the waterproofing of the deck;
- cleaning the bridge bearings;
- painting all the surface with acrylic paint to protect the concrete against carbonation and chlorites.





ありがとう!

OBRIGADO!

THANK YOU!